STATUS OF ESTUARINE CROCODILES IN THE POPULATED COAST OF NORTHEAST QUEENSLAND

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Kofron, C.P. & Smith, R. 2001 06 30: Status of Estuarine Crocodiles in the populated coast of northeast Queensland. *Memoirs of the Queensland Museum* **46**(2): 603-610. Brisbane. ISSN 0079-8835.

Tully to Cooktown encompasses 325km of coastline in northeast Queensland. During the past 50 years this area has undergone tremendous urban, rural residential and agricultural development. North of Cooktown human population density is low. Since 1990, Estuarine Crocodiles (*Crocodylus porosus*) have attacked six people in Queensland resulting in one death and five serious injuries. Two attacks occurred in the study area in Cairns during 1997 and 1998. Consequently public perception is that numbers of crocodiles have increased greatly since cessation of commercial hunting in 1974 and elimination of removal zones around cities and towns in 1991, and public concern for human safety from crocodile attack is high. We surveyed the major waterways between Tully and Cooktown for Estuarine Crocodiles from June 1996 to May 1998: Hull R, Maria Ck, Moresby R, Johnstone R, Russell/Mulgrave R, Trinity Inlet, Barron R, Daintree R, Annan R and Endeavour R. These waterways comprise most of the habitat occupied by Estuarine Crocodiles between Tully and Cooktown. We surveyed 346km of waterway, sighting 146 crocodiles at densities 0.11/km to 1.00/km. Overall density was 0.34/km, which relative to most waterways in Cape York Peninsula is low. Contrary to public perception, the crocodile population between Tully and Cooktown is of low density. Certain human activities such as urban, rural residential and agricultural development, clearing of riparian vegetation, disturbance by motor boats, commercial gill netting in estuaries, and removal of crocodiles appear to be keeping crocodile numbers low in this area. ❐ *Crocodiles, north Queensland, estuarine.*

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The Estuarine Crocodile, *Crocodylus porous*, is the world's largest living crocodile, with total lengths up to 9m (Groombridge, 1987). Its large size and predatory habits cause special management problems because most people do not want to live or recreate near large, dangerous, predatory wildlife. The geographic range is greater than for any other crocodile, extending from Vanuatu and Solomon Islands in the east, across northern Australia, New Guinea, Indonesia, Borneo, Philippine Islands and Southeast Asia to eastern India and Sri Lanka. Despite this enormous geographic range, its populations in most countries are very severely depleted with continuing decline (Groombridge, 1987). Prospects for survival appear to be poor except in Indonesia, Papua New Guinea and Australia (Ross, 1998).

The geographic range in Queensland extends from Fitzroy R system (23°27'S), along the eastern coast to islands of Torres Strait, along the western coast of Cape York Peninsula, to the Northern Territory. In Queensland, Estuarine Crocodiles inhabit coastal waterways, and freshwater sections of rivers where they may travel several hundred kilometres inland (Taplin, 1987). Estuarine crocodiles are listed as 'vulnerable', if threatening processes continue (Department of Environment and Heritage, 1994).

Since 1990 Estuarine Crocodiles have attacked 6 people in Queensland resulting in 1 death and 5 serious injuries. Two recent attacks occurred in Cairns. On 28 November 1997, a man swimming at Yorkey's Knob Beach was attacked by a 2.6m crocodile, suffering puncture wounds on head, shoulder and back. On 6 February 1998, a teenage girl swimming in a mangrove-lined drain of Chinaman's Ck was attacked by a 3.1m crocodile, suffering deep puncture wounds in both legs and a broken ankle. Public perception is that crocodile numbers have increased since cessation, in 1974, of commercial hunting, and elimination, in 1991, of removal zones around cities and towns. Consequently public concern for human safety from crocodile attack is

especially high. The purpose of this study, therefore, was to determine the current status of Estuarine Crocodiles in the populated coast of northeast Queensland.

Some rivers between Tully and Cooktown were surveyed previously by Queensland National Parks and Wildlife Service from 1984-1986 (Taplin, 1989) and in 1991 (Kreiger & Fell, 1991). Although no data exist on crocodile numbers prior to commercial hunting in Queensland, crocodile numbers were apparently reduced to low levels relative to pre-hunting abundance (Taplin, 1987). It seems probable that the combination of commercial hunting and removal zones in late 1980s to early 1990s reduced crocodile numbers to very low levels within the study area. However, some people argue that these tidal waterways, mostly short and with headwaters in mountains to the west, were never a major crocodile breeding area and never contained high numbers, cooler water temperatures being a determining factor.

STUDY AREA

Cairns (16°55'S) is 119km N of Tully (17° 56'S) and 169km S of Cooktown (15°28'S) on the eastern coastal plain in the Tropical Rainforest Bioregion. Rivers on the NE coast between Tully and Cooktown are not extensive. Tully to Cooktown encompasses 325km of coast, and here the coastal plain does not extend beyond 30km inland where it is bounded by mountain ranges, including Bellenden Ker range with Queensland's highest peak (Bartle Frere 1,622m).

During the past 50 years the coastal plain between Tully and Cooktown has undergone major urban, rural residential and agricultural development. Total human population between Tully and Cooktown is 168,855 (Cook et al., 1997), 76% (128,022 people) living in Cairns (Centre for Applied Economic Research and Analysis, 1997). In addition to Tully, Cairns and Cooktown, other human population centres are Mission Beach/Innisfail (Johnstone Shire) and Port Douglas/Mossman areas (Douglas Shire). North of Cooktown, population density is low and centres are sparse.

There are 10 major waterways between Tully and Cooktown (south to north): Hull R, Maria Ck, Moresby R, Johnstone R, Russell/Mulgrave R, Trinity Inlet, Barron R, Daintree R, Annan R and Endeavour R. Only one species of crocodile (*C. porosus*) inhabits this area, and tidal waterways comprise most of its habitat. Six flow through towns or cities: Hull R (Tully); Johnstone R (Innisfail); Russell/Mulgrave R, Trinity Inlet, Barron R (Cairns); and Endeavour R (Cooktown).

METHODS

We surveyed the major waterways between Tully and Cooktown for Estuarine Crocodiles from June 1996 to May 1998. Surveys were conducted by spotlighting from a small motorboat at night within 3 hours each side of low tide. Tidal reaches of waterways were surveyed, including adjacent freshwater sections passable by small motorboat. Total length of each crocodile was estimated and recorded in size classes: 0.2-0.4m (hatchling/yearling), 0.5-1.0m, 1.1-2.0m, 2.1-3.0m, 3.1-4.0m and 'eyes only' (crocodile sighted only by eye shine). Locations of crocodiles were determined by global positioning systems and topographic maps. We compare our data to surveys by Taplin (1987) and Kreiger & Fell (1991). However, we are unable to make statistical comparison.

Surveys were conducted to international standards (Bayliss, 1987; Kofron, 1992) with recognition of inherent weaknesses (Webb & Smith, 1987). For example, wariness in crocodiles is a function of size (Webb & Messel, 1979), older and larger crocodiles being more 'wary' and thus difficult to detect. However, we surveyed tidal rivers, which relative to other aquatic habitats (e.g. vegetated swamps) are easy' to survey. In such areas a higher proportion of total number of crocodiles present is seen (Webb et al., 1987). Following convention, we define density as number of crocodiles observed per kilometre of waterway, excluding hatchlings and yearlings. Distance of a waterway from Cairns is measured from the central business district for this study.

RESULTS AND DISCUSSION

We sighted 146 crocodiles in 346km of waterway (Table 1): 0.2-0.4m ($n = 29$), 0.5-1.0m (23), 1.1-2.0m (41), 2.1-3.0m (19), 3.1-4.0m (10) and eyes only (24). Crocodile densities in river systems were 0.11/km to 1.00/km. Overall crocodile density in waterways between Tully and Cooktown was 0.34/km.

HULL RIVER. Hull R system is east of Tully with a catchment area of 12,996ha (Russell & Hales, 1997), originating in Walter Hill Range to the west (highest peak 1,068m) and draining a

TABLE 1. Results of spotlight surveys of Estuarine Crocodiles (*Crocodylus porosus*) in major waterways between Tully and Cooktown from June 1996 to May 1998. Density is number of crocodiles sighted per kilometre of waterway, excluding hatchlings and yearlings (0.2-0.4m total length).

Waterway	km Surveyed	No. of Crocs	Estimated Lengths					Eyes only	Density
			0.2-0.4m	0.5-1.0m	1.1-2.0m	2.1-3.0m	3.1-4.0m		
Hull River	38	21	12	0	3	3	2	1	0.24
Maria Creek	17	2	0	1	1	0	0	0	0.12
Moresby River	44	6	0	0	3	0	0	3	0.14
Johnstone River	41	7	1	3	3	0	0	0	0.15
Russell/Mulgrave R	63	9	2	2	4	0	1	0	0.11
Trinity Inlet	40	20	0	4	10	3	0	3	0.50
Barron River	22	7	0	0	2	3	2	0	0.32
Daintree River	25	21	6	8	4	0	0	3	0.60
Annan River	12	12	0	1	2	4	2	3	1.00
Endeavour River	44	41	8	4	9	6	3	11	0.75
Total	346	146	29	23	41	19	10	24	0.34

narrow coastal plain. Hull R and North Hull R are the major waterways, converging 2km from the coast into an estuary. Hull R flows through Hull R National Park (3,070ha) immediately adjacent to the coast.

The catchment is 76% forested, almost all in Wet Tropics World Heritage Area, and 14% under agriculture (sugarcane). Mangrove (1,326 ha), other swamp forest (81ha, predominantly *Melaleuca*) and rainforest comprise the existing natural vegetation. Although the only urban centre is the township Hull Heads (Russell & Hales, 1997), the Hull R system is heavily used for recreational boating and fishing. Commercial gill netting occurs at low to moderate level.

We surveyed 38km on 5-7 April 1997, sighting 21 crocodiles at 0.24/km: 0.2-0.4m (n = 12), 1.1-2.0m (3), 2.1-3.0m (3), 3.1-4.0m (2) and eyes only (1). Two nests were sighted.

MARIA CREEK. Maria Ck system is a group of small coastal streams 100km S of Cairns originating in Walter Hill Range to the west and draining a narrow coastal plain. It flows through Maria Ck National Park (749ha) immediately adjacent to the coast and in Wet Tropics World Heritage Area. Catchment area is 24,642ha, 49% cleared predominantly for agriculture (sugarcane; Russell & Hales, 1997). The main waterway is 25km long with a relatively large estuary, sheltered and lengthened by a sandspit extending south from Kurrimine Beach. Half of the national park is mangrove (350ha), the remainder other swamp forest and rainforest (Australian Nature Conservation Agency, 1996).

Maria Ck National Park is an important wetland in Australia. Maria Ck system is heavily used for recreational boating and fishing, and commercial gill netting occurs at low level. High levels of nutrients and sediments in runoff from adjacent agricultural lands may be impacting on the wetlands (Australian Nature Conservation Agency, 1996). Catchment area contains El Arish, Mission Beach and Kurrimine townships.

We surveyed 17km on 4-5 April 1997, sighting two crocodiles: 0.5-1.0m (n = 1) and 1.1-2.0m (1). Density was 0.12/km.

MORESBY RIVER. Moresby R system is 80km south of Cairns, a wetland 24km long and 12km wide, mostly in Wet Tropics World Heritage Area. Catchment area is 126km^2, 48% remaining as natural vegetation, and with a population of 300 (Eyre & Davies, 1996). Moresby R communicates with the Coral Sea through a restricted passage in Moresby Range, with a broad sheltered estuary west of the range. The southern system is bounded to the east by a series of sand dunes. The tidal reach of Moresby R is 20km long with headwaters in Basilisk Range, a low range in the western coastal lowlands. Natural vegetation is mangrove, other swamp forest and rainforest, and the estuary contains significant seagrass beds. Moresby R system is an important wetland in Australia (Australian Nature Conservation Agency, 1996).

Coastal lowlands north, south and west of Moresby R system have undergone extensive clearing for agriculture (sugarcane). Mourilyan Harbour, at northern end of the estuary and sheltered by Moresby Range, loads sugar onto

sea-going vessels. Moresby R is heavily used for recreational fishing and boating, and commercial gill netting occurs at low level.

We surveyed 44km on 31 January to 4 February 1997, sighting six crocodiles: 1.1-2.0m (n = 3) and eyes only (3). Density was 0.14/km.

JOHNSTONE RIVER. North Johnstone R (125km) and South Johnstone R (90km) are the main waterways of Johnstone R system 64km south of Cairns, originating on Atherton Tableland and flowing through vast rainforest on the eastern escarpment of Bellenden Ker Range. Catchment area is 163,050ha (population 17,860; Eyre & Davies, 1996): 54% rainforest, predominantly on slopes; 38% under agriculture (cattle, sugar cane, bananas), rural residential and urban uses, predominantly in coastal lowlands and Atherton Tableland; and 8% mangrove and other swamp forest (Pitts, 1993). Along the lower river system much clearing has occurred to very edge of the stream bank.

North Johnstone R is 43km long in the coastal plain, and South Johnstone R 31km. The two rivers converge at Innisfail forming Johnstone R estuary 5km long. Johnstone R flows through centre of Innisfail, population 8,987 (Cook et al., 1997). Innisfail is home for a commercial fishing fleet, and the river is also heavily used for recreational boating and white-water rafting. Johnstone R has been closed to commercial gill netting for 30-40 years.

We surveyed 41km on 10-12 January 1997, sighting 7 crocodiles at 0.15/km: 0.2-0.4m (n = 1); 0.5-1.0m (3); 1.1-2.0 (3). Johnstone R system (11km) was surveyed previously in 1986 (Taplin, 1989), 6 crocodiles sighted at 0.55/km: 0.5-1.8m (n = 2), 1.9-3.0m (3) and eyes only (1). Densities are low and show no increase.

RUSSELL/MULGRAVE RIVERS. Russell R and Mulgrave R flow through agricultural and rural residential lands of south Cairns, headwaters in mountains to the west. The lower river system is in a narrow plain between Bellenden Ker Range and Graham Range/Malbon Thompson Range to the east coastally. Russell R flows northeast and Mulgrave R southeast. The two rivers converge 1km from the sea to form Mutchero Inlet, a constricted passage through submerged parts of Graham Range to the south and Malbon Thompson Range to the north. Catchment area of Russell R is 57,000ha, and Mulgrave R 145,000ha (Australian Nature Conservation Agency, 1996).

Surrounding natural vegetation is mangrove, other swamp forest and rainforest, although most floodplain in coastal lowland has been cleared. Forty-eight percent of the catchment area remains in natural state and is Wet Tropics World Heritage Area; and 27% is under agriculture (sugarcane). Russell R flows through Russell R National Park (4,100ha), an important wetland in Australia (Australian Nature Conservation Agency, 1996). Tidal sections of the Russell/Mulgrave R are heavily used for recreational fishing and boating, and adjacent freshwater sections for swimming and rafting. The rivers have been closed to commercial gill netting for more than 10 years.

We surveyed 63km (Russell R 38km, Mulgrave R 25km) 18-21 January 1997, sighting 9 crocodiles at 0.11/km: 0.2-0.4m (n = 2), 0.5-1.0m (2), 1.1-2.0m (4) and 3.1-4.0m (1). One problem crocodile (1.9 m) was removed from Mulgrave R during the study because it was in a freshwater swimming area. Russell/Mulgrave R (27km) were surveyed previously in 1991 (Kreiger & Fell, 1991), seven crocodiles sighted at 0.26/km: 0.5-1.0m (n = 1), 1.1-1.8m (2) and eyes only (4). Also, 24km were surveyed in 1984 (Taplin, 1989), 2 crocodiles sighted at 0.04/km: 0.2-0.4m (n =1) and eyes only (1). Densities are consistently low and show no increase.

TRINITY INLET. Trinity Inlet is 18km long by 6km wide in north-south direction, comprising 6,475ha: mangrove 3,600ha, seagrass 1,000ha, open water 940ha, tidal flats 900ha, salt flats 20ha, freshwater swamp 10ha and sand ridge 5ha. Catchment area is 30,000ha. Trinity Inlet is a blind estuary, previously the mouth of Mulgrave R whose communication with the sea has shifted south (Australian Nature Conservation Agency, 1996).

Cairns surrounds Trinity Inlet: Cairns Port at its mouth; urban development and industry on its western side; and rural residential and agriculture on its southern and eastern sides. Most of the previously fringing freshwater swamp forest has been cleared. The system is heavily used for recreational fishing and boating, and also by large sea-going vessels; commercial gill netting occurs at extremely high level. Despite proximity to a major population centre, the ecosystem is intact and overall water quality good (Australian Nature Conservation Agency, 1996).

We surveyed 40km on 7-9 and 20 May 1998, sighting 20 crocodiles at 0.50/km: 0.5-1.0m (n = 4), 1.1-2.0 (10), 2.1-3.0 (3) and eyes only (3).

Also, we previously surveyed 40km of Trinity Inlet on 18 April and 19 May 1997, sighting 13 crocodiles at 0.33/km: 0.5-1.0m (n = 2), 1.1-2.0m (4), 2.1-3.0m (5), 3.1-4.0m (1) and eyes only (1). Although we sighted no hatchlings, Keith Cook (Cairns Crocodile Farm, pers. comm) observed one in 1997. In addition, courtesy Mark Read (Queensland Parks and Wildlife Service), we searched for nests by helicopter on 21 February 1998 but sighted none. Two problem crocodiles were removed during the study: one (3.1m) from Chinaman's Ck (February 1998) that attacked a teenage girl, and a second (1.5m) from the same drain in April. Trinity Inlet (55km) was surveyed previously in 1991 (Kreiger & Fell, 1991), seven crocodiles sighted at 0.13/km: 0.5-1.0m (n = 1), 1.1-1.8m (2) and eyes only (4). Densities are consistently low and show no increase.

BARRON RIVER. Barron R is one of the longest easterly-flowing rivers (165km) in Cape York Peninsula, with headwaters in Atherton Tableland at 1234m elevation (North Queensland Joint Board, 1997). It breaches Macalister/Lamb Ranges through a major gorge (6km length) then forms a delta (50km^2) in the narrow coastal plain (8km wide). Barron R flows through Cairns just north of the urban centre, Machan's Beach community at its mouth. Catchment is 200,000ha, population 42,000.

Natural vegetation along lower Barron R is mangrove, other swamp forest and rainforest, most cleared for sugarcane and residential land use. A significant area of mangrove (6km^2) remains at the mouth. Queensland Government (Department of Primary Industries, 1993) is concerned about catchment condition, particularly erosion, weeds, urban expansion, nutrient enrichment, impacts on wildlife and loss of wetlands. Tidal section of the river is heavily used for recreational fishing and boating, and adjacent freshwater section for swimming and rafting. Commercial gill netting occurs at low level.

We surveyed 22km (tidal reaches) on 4-6 May 1998, sighting seven crocodiles at 0.32/km: 1.1-2.0m (n = 2), 2.1-3.0m (3) and 3.1-4.0m (2). Also, we surveyed the same tidal reaches previously 28-29 June 1996, sighting seven crocodiles at 0.32/km: 0.5-1.0m (n = 1), 1.1-2.0m (1) and 2.1-3.0m (5). Densities are consistently low. Two problem crocodiles (2.6m each) were removed during the study, one from Richters Ck (29 January 1997) frequenting swimming beaches and one from Thomatis Ck (9 December 1997) that attacked a swimmer at Yorkey's Knob Beach.

DAINTREE RIVER. Daintree R (120km length) is 78km northwest of Cairns, headwaters in Great Dividing Range. Catchment is 2125km^2, 90% in Wet Tropics World Heritage Area and most protected in Daintree National Park and Dagmar Range National Park, population 1000. Rainforest comprises 74% of catchment, originally 90%. The estuary is 5km long, tidal influence extending 24km upstream. The lower 13km of Daintree R, up to 10km wide with mangrove and other swamp forest, is an important wetland (Australian Nature Conservation Agency, 1996; Eyre & Davies, 1996).

Daintree R in the coastal lowlands occupies a narrow valley between Thornton Range to the north and Dagmar Range to the south. One-half (16,400ha) of this floodplain is cleared for sugarcane (12,000ha) and cattle (4,400ha), the other half (17,300ha) remaining as mangrove, other swamp forest and rainforest (Burrows, 1998). Mangrove is most extensive at river mouth to 6km upstream. Daintree R is heavily used for recreational boating, and also commercial boating for wildlife tours. The river was closed to commercial gill netting about 12 years ago.

We surveyed 25km (starting 7km above river mouth at ferry crossing) on 5 September 1997, sighting 21 crocodiles: 0.2-0.4m (n = 6), 0.5-1.0m (8), 1.1-2.0m (4) and eyes only (3). Density was 0.60/km, however fog made visibility poor. One crocodile (2.4m) that attacked a dog was removed during the study (8 May 1997). Daintree R (31km) was surveyed previously by Kreiger & Fell (1991), 27 crocodiles sighted at 0.85/km: 0.2-0.4m (n = 1), 0.5-1.0m (17), 1.1-1.8m (3), 1.8-4.0m (3) and eyes only (3). Also, Taplin (1989) surveyed 21km in 1984, sighting 16 crocodiles at 0.75/km: 0.5-1.8m (n = 9), 1.9-3.0m (2) and eyes only (5). Densities are consistently low and show no increase.

Also in Douglas Shire during the study, 1 problem crocodile (1.8m) was removed at Wonga Beach (7km south of Daintree R); 2 (3.4m each) from Mossman R (17km south of Daintree R; 29 January and 23 March 1998) that took dogs; and 1 (2.1m) from Bloomfield R (41km north of Daintree R, 10 February 1998).

ANNAN RIVER. Annan R is 6km south of Cooktown and is least disturbed of the major

waterways. Catchment is 750km^2, with population 300 (Eyre & Davies, 1996). Ninety percent of catchment retains natural vegetation (40% rainforest, predominantly upper half; 40% dry *Eucalyptus* woodland, predominantly lower half), and 10% cleared for cattle. The tidal section is bounded immediately by mangrove, other swamp forest and rainforest. The estuary is 6km length. Recreational boating occurs at low to moderate level in the tidal section, and commercial gill netting at moderate level.

We surveyed 12km (tidal reaches) on 9-10 October 1997, sighting 12 crocodiles at 1.00/km: 0.5-1.0 (n = 1), 1.1-2.0 (2), 2.1-3.0 (4), 3.1-4.0 (2) and eyes only (3). Annan R (11km) was surveyed previously by Kreiger & Fell (1991), sighting six crocodiles at 0.55/km: 1.9-4.0m (n = 1) and eyes only (5). Densities are low but may indicate a slight increase.

ENDEAVOUR RIVER. Endeavour R system has two major channels: Endeavour R flowing west to east, and Endeavour R Right Branch north to south. Cooktown is on the southern banks of Endeavour R at its mouth, population 1411 (Cook et al., 1997). Cooktown McIvor River Rd parallels Endeavour R for 30km near Cooktown, and adjacent land is under rural residential use and agriculture (peanuts, corn, bananas); however only little clearing has encroached to the banks of Endeavour R. Vegetation along Endeavour R Right Branch remains predominantly natural.

The estuary is 5km long, its upper half in Endeavour R National Park (2,170ha). Endeavour R is 500m wide at its mouth, narrowing to 100m at junction with Endeavour R Right Branch 11km upriver. Vegetation in the tidal area is mangrove; along freshwater sections of the river, rainforest; and along freshwater creeks, *Melaleuca* swamp. Recreational boating occurs at moderate level. The river was closed to commercial gill netting about 30 years ago.

We surveyed 44km on 14-16 September 1997, sighting 41crocodiles at 0.75/km: 0.2-0.4m (n = 8), 0.5-1.0m (4), 1.1-2.0m (9), 2.1-3.0m (6), 3.1-4.0m (3) and eyes only (11). Two crocodiles (3.7m, 3.8 m) frequenting Cooktown wharf were removed during the study. Endeavour R system (28km) was surveyed previously by Kreiger & Fell (1991), sighting 28 crocodiles at 0.96/km: 0.2-0.4m (n = 5), 0.5-1.0m (16), 1.1-1.8m (1), 1.9-4.0m (2) and eyes only (4). Densities are consistently low and show no increase.

MANAGEMENT CONSIDERATIONS

Densities of Estuarine Crocodiles in waterways between Tully and Cooktown range from 0.11/km to 1.00/km. In total, we surveyed 346km of waterway between Tully and Cooktown, sighting 146 crocodiles at overall density 0.34/km. Previously Kreiger & Fell (1991) surveyed five waterways, sighting crocodiles at overall density 0.45/km. In these five waterways we sighted crocodiles at density 0.47/km. Also, Taplin (1989) surveyed 3 waterways in 1984-1986, sighting crocodiles at overall density 0.41/km. In these 3 waterways we sighted crocodiles at overall density 0.22/km. The densities are consistently low and show no increase.

Overall crocodile density between Tully and Cooktown (0.34/km) is low relative to most waterways on Cape York Peninsula: 0.7/km, rivers in Lakefield National Park (165km northwest of Cooktown; Read & Miller, 1998); 5.9/km and 10.5/km, Wenlock R and Tentpole Ck (northwest tip of Cape York Peninsula), respectively (Read, 1998); and 0.3/km to 3.6/km, other rivers on western Cape York Peninsula (Read, 1998). In the Northern Territory, Estuarine Crocodile populations are recovering, with mean annual rate of increase 2-3% reported in several rivers (Webb et al., 1987) and overall annual rate of population increase 8% (Bayliss, 1987).

Estuarine Crocodiles nest in the wet season, and flooding is a major threat to egg survival. In the Northern Territory, mean egg survivorship is 25%, inundation of nests the major cause of mortality (Webb et al., 1987). In some areas flooding accounted for 100% egg mortality.

No effort was made to locate nests except for one helicopter search of Trinity Inlet, but none was seen. However, 2 nests were observed near the Hull R, and 1 near the Bloomfield R subsequently inundated (Tony Frisby, Queensland Parks and Wildlife Service, pers. comm.). In addition, hatchlings/yearlings were seen in several rivers: Hull R (12), Johnstone R (1), Russell/Mulgrave R (2), Trinity Inlet (1, Keith Cook, Cairns Crocodile Farm, pers. comm.), Daintree R (6) and Endeavour R (8). There was no evidence of nesting in Maria Ck, Moresby R, Barron R, Mossman R or Annan R. In total, 30 hatchlings/yearlings were observed in 346km of waterway, which is a low number.

Crocodile densities in tidal rivers are partly a function of proximity to successful nesting areas.

For example in the Northern Territory, Webb et al. (1987) observed crocodiles at density 3.2/km in tidal rivers with successful nesting areas, and 0.7/km without. We attribute the low number of hatchlings/yearlings between Tully and Cooktown to negative impacts of human activities, largely preventing successful nesting.

Extensive deforestation and development in the catchment of some rivers probably effect greater rises in water levels than occurred previously, partially accounting for the paucity of successful nesting. In addition, many river banks previously available for nesting are now cleared to water's edge, and disturbance by motor boats may also discourage nesting. The human population and agricultural development were identified previously as causing significant degradation of crocodile habitat between Tully and Cooktown (Taplin, 1987). Further, Taplin (1987) referred to this crocodile population as depleted', with only small numbers at low densities.

There are 16 protected areas with crocodile habitat between Tully and Cooktown. They range from 6ha to 76,000ha. Daintree National Park is the largest, however it encompasses predominantly Great Dividing Range and lowland rainforest, with relatively little crocodile habitat. The next 3 largest are Cedar Bay National Park (5,650ha), Russell R National Park (4,100ha) and Ella Bay National Park (3,710ha). The fifth largest is Hull R National Park (3,070ha) and almost all crocodile habitat (waterway, mangrove, swamp forest). Crocodiles are at low denisty here too, 0.24/km.

Estuarine Crocodiles are highly mobile, and probably no protected area between Tully and Cooktown contains sufficient habitat for the life cycle. Taplin (1987) believed adult crocodiles moved in and out of protected areas, juveniles and subadults dispersing into surrounding non-protected areas. Commercial gill netting in tidal rivers was identified as a major threatening factor to crocodiles (Taplin, 1987), but the impact remains to be quantified. This activity continues in six major waterways between Tully and Cooktown. Johnstone, Russell/Mulgrave, Daintree and Endeavour Rivers are closed to this fishing.

Despite low densities, problem crocodiles are not infrequent in the study area, often as a result of human behaviour, such as discarding fish scraps at public facilities (boat ramp, wharf, jetty). Two crocodile attacks occurred in Cairns during the study, and public perception is now that large numbers of crocodiles occur between Tully and Cooktown. However many people use these waterways daily, usually without incident, and consequently some crocodiles may be coming less wary and also more visible. Twelve problem crocodiles were removed during the study: 2 had attacked humans, 2 from swimming areas, 3 had attacked dogs, 2 frequented a wharf and 3 were otherwise threats to humans. Removed crocodiles measured 1.1-2.0m ($n = 3$), 2.1-3.0m (4) and 3.1-4.0m (5).

In the interests of public safety, the Queensland Parks and Wildlife Service initiated a Trial Intensive Management Area for Crocodiles in May 1998. This 3-year trial program targets all crocodiles for removal in designated areas near Cairns, Port Douglas and Mossman. Also, an education program provides information on appropriate and safe behaviour in crocodile habitat. Research is focussed on surveys and on-going monitoring. The survey data presented here precede implementation of the crocodile removal zone and comprise baseline data for comparison against future surveys.

CONCLUSIONS

Contrary to public perception, the crocodile population between Tully and Cooktown exists at low density, showing no increase over 14 years. Human activities such as urban, rural residential and agricultural development, clearing of riparian vegetation, disturbance by motor boats, commercial gill netting in estuaries, and removal of crocodiles appear to be keeping crocodile numbers low.

ACKNOWLEDGEMENTS

The following people rendered assistance: Angela Chapman, Tony Frisby, Ian King, Gordon LaPrak, Jeffrey Miller, Frank Nissan, Richard Orchard, Mark Read, Rupert Russell, Clay Smith, Willie Smith, Laurie Taplin and Brent Vincent.

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